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AUTHOR Bamford, Kathryn W.; Mizokawa, Donald T.
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ABSTRACT

The fourth-year update of a longitudinal study examined the progress of the 31 remaining members of 2 classes in the first cohort of a Spanish immersion program and their standard-program monolingual comparison group of 15 students. Achievement gains were measured on standardized tests of mathematics and language skills. Results provided new evidence supporting the hypothesis that degrees of primary-school bilingual development correlate with development of higher-order mathematical skills. However, while an earlier report of the longitudinal study showed significant gains in nonverbal development by the immersion students at grade 2, mathematics and language achievement data do not indicate a corresponding advantage for the immersion students at grades 4 and 5. At the intermediate grades, the immersion children were generally performing on par with their monolingual comparison group on standardized achievement measures. It is concluded that the study's results support the developmental-interdependence hypothesis and Vygotsky's theory of cognitive development, but not enhanced achievement among additive-bilingual children. A 31-item bibliography is included. (MSE)

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Spanish-Immersion Children in Washington State: Fourth Year of a Longitudinal Study

Kathryn W. Bamford and Donald T. Mizokawa

University of Washington

College of Education

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Abstract

Children educated in additive-bilingual contexts may demonstrate enhanced verbal and nonverbal achievement. This study compared longitudinally the language and mathematics achievement of 2 cohorts of additive-bilingual (immersion) and monolingual children. A quasi-experimental pretest-posttest design was employed, with program as independent variable. Dependent variables included the grade 4 *Metropolitan Achievement Test* (MAT6) and the grade 5 *Degrees of Reading Power* and mathematics competency tests. Contrary to expectation, a MANCOVA with grade 2 verbal and nonverbal ability, sex and age as covariates showed no significant differences in mathematics achievement between groups. However, a significant relationship was demonstrated between grade 2 bilingual development and grade 4 mathematics achievement among children of the first cohort. The spelling, word recognition and language subtests of the MAT6 at grade 4 revealed performance deficits by one immersion cohort. Results supported the developmental-interdependence hypothesis and Vygotsky's theory of cognitive development, but not enhanced achievement among additive-bilingual children.

Spanish-Immersion Children in Washington State: Fourth Year of a Longitudinal Study

Faculty psychologists of the last century argued that formal discipline, the study of formal systems of knowledge such as Latin and mathematics, would improve the mind's abilities in general (Lewis, 1905). The pursuit of formal discipline was abandoned at the turn of the twentieth century with Thorndike and Woodworth's (1901) apparent demonstration of the failure of transfer of training, and the concurrent rise of experimental psychology. Since mid-century, however, cognitive psychologists have returned to an examination of higher mental processes (Sexton, 1978) and a contemporary redefinition of formal discipline (e.g., Lehman, Lempert & Nisbett, 1988).

Not surprisingly, research into the development of bilingual children followed a parallel course as behavioral science matured over the course of the twentieth century. Early psychometricians studying large groups of bilingual immigrant children in the first half of the twentieth century concluded from their experiments that bilingualism contributes to "mental confusion" in children (Darcy, 1953). Today, in contrast, researchers are aware of methodological errors in early experimental research conducted among bilingual children (Diaz, 1985; Hakuta, Ferdman & Diaz, 1986) and attention has turned from the possible negative effects of bilingualism to investigation of the general cognitive development of children in additive-bilingual settings. An

increasing body of research has been viewed in support of a positive relationship between second-language acquisition and several reasoning abilities among children, including nonverbal problem-solving, divergent thinking skills, and field independence (for a review, see Cummins, 1976).

Where cognitive advantages of bilingualism have been found among additive-bilingual children, few studies have continued to follow the children's development in order to enhance understanding of their growth. This study sought to respond to this need through the extension of our investigation of the cognitive and language development of two groups of Spanish-immersion children and their counterparts in a standard-English program into a fourth year.

Nonverbal problem-solving

The theoretical foundation of the argument that the acquisition of second-language ability may enhance the development of certain cognitive abilities may be found in the work of Vygotsky (1934/1986) who argued "The influence of instruction on development had been postulated by the theory of formal discipline only in relation to such subjects as mathematics and languages, which involve vast complexes of psychic functions. . . . It stands to reason that in the higher processes emerging during the cultural development of the child formal discipline must play a role that it does not play in the more elementary process: All the higher functions have in common awareness, abstraction and control" (p. 178-179). Indeed, contemporary research

indicates that additive-bilingual children outperform their monolingual counterparts on tasks requiring high levels of cognitive control (Bialystok, 1986a, 1986b).

The superior cognitive control of additive-bilingual children may augment the development of nonverbal skills. Evidence is provided by Samuels and Griffore (1979), who reported significant gains in nonverbal ability by children in a French-immersion K-1 program over their comparison classroom, using the performance (nonverbal) subtests of the *Weschler Intelligence Scales for Children* as a dependent variable. Likewise, an early report of the present longitudinal investigation found similar results among Spanish-immersion children and their monolingual counterparts over the second-grade year using Raven's *Coloured Progressive Matrices* as a measure of nonverbal development (Bamford & Mizokawa, 1991). In addition, Harley, Hart and Lapkin (1986) found evidence of enhanced nonverbal development among bilingual children in a retrospective analysis of 22 matched pairs of monolingual and bilingual children at grades 4 and 6 as measured by the nonverbal battery of the *Canadian Cognitive Abilities Test*.

The relationship between nonverbal ability and bilingual development has been demonstrated as well in within-group analyses of data from primary grade Spanish-English bilingual-education children (Hakuta & Diaz, 1985; Hakuta, 1987) and from Spanish-immersion children in both cohorts participating in the current study

at grade 2 (Bamford & Mizokawa, 1989, 1990, 1991b), using Raven's matrices as the measure of nonverbal ability.

Thus, evidence from both between-group and within-group investigations of bilingual development indicates a relationship between bilingual development and several measures of nonverbal problem-solving. However, it is not clear whether the indicated enhancement of nonverbal ability in the early school years will be correspondingly seen in terms of mathematics achievement in the intermediate grades.

Native-Language Development

Contemporary expectations for the development of native-language skills of bilingual children are anchored in arguments set forth independently by several theorists, including Chomsky (1972), Cummins (1981) and Lambert (1984). Common to the work of each is an expression of the unitary nature of human language ability. This premise is extended in the developmental-interdependence hypothesis of Skutnabb-Kangas and Toukomaa (cited in Cummins, 1978) which predicts that the growth of skills in any one language will be reflected by corresponding development of the same abilities in a second language.

Lambert (1984) examines the development of bilingual children in more than strictly psychological terms through an examination of the social context of bilingual development. Settings where children are positively motivated to acquire a second language while receiving

support for native-language development at home and in the community are termed by Lambert *additive-bilingual* contexts. Lambert argues that children educated in additive-bilingual contexts will suffer no retardation of native-language development while acquiring a second language at school.

Contemporary research investigating the language development of bilingual children confirms the positive relationship between native- and second-language ability, thus supporting the notion of a unitary human language ability (Bamford & Mizokawa, 1989, 1990, 1991b; Hakuta, 1987). Lambert's notion of additive bilingualism has been confirmed in research conducted among immersion children as well (for a review see Bamford & Mizokawa, 1989). While early populations of immersion children were predominantly middle-class, recent investigations have provided evidence that confirms the notion of additive bilingualism beyond the middle class in studies of working-class children which reveal

no significant differences in native-language development between samples of working-class immersion and monolingual children (Holobow, Genesee, Lambert, Gastright & Met, 1987; Holobow, Genesee & Lambert, 1991).

Recently, Harley, Hart and Lapkin (1986) have asserted that although children in additive-bilingual immersion programs receive significantly less native-language instruction, they may demonstrate enhanced native-language achievement as an outcome of the bilingual

experience, a contention that received subsequent support in their retrospective analysis of data collected from immersion children and matched monolingual peers (N = 44) over a 6-year period.

Our Research

This study reports data from the fifth observation of the cognitive and language development of children enrolled in a Spanish-immersion program (SIP) in Washington State that began in 1987 (see Bamford & Mizokawa, 1989, 1990, 1991a, 1991b). Scores from the first cohort of children to enter the SIP program were compared longitudinally to those of a standard-program comparison group on measures of language and mathematics achievement at grade 4 and reading and mathematics achievement at grade 5. Likewise, members of the second cohort of SIP children were compared longitudinally to their monolingual peers on a measure of language and mathematics achievement at grade 4.

In view of the contemporary redefinition of formal discipline and the significant body of research literature indicating a relationship between additive bilingualism and nonverbal problem-solving, we hypothesized that members of each cohort of SIP children would outperform their standard-program comparison classrooms on measures of mathematics achievement at grades 4 and 5.

Our second hypothesis derived from arguments for the unitary nature of human language potential and the developmental-interdependence hypothesis. Our expectation was extended as well by

recent evidence of enhanced native-language development among immersion children. Thus, we were interested in testing the hypothesis that the SIP groups participating in this study would outperform their monolingual counterparts on measures of reading and language achievement at grades 4 and 5. For all comparisons, alpha = .05.

Method

Subjects

Subjects included the remaining members of 2 classrooms of the first cohort of SIP children of whom 13 boys and 18 girls remained in 1990, and their standard-program comparison group of which 9 boys and 6 girls likewise were enrolled in 1990. Verbal and nonverbal scores were available for use as covariates in the longitudinal analyses for 1 classroom of the Cohort 1 students beginning in the fall of grade 2. The children in the fall sample have been of particular interest because they showed significant gains in nonverbal problem-solving ability over their comparison classroom over the course of the second grade year (Bamford & Mizokawa, 1991b). The advantage in development of nonverbal skill was sustained over the third-grade year (Bamford & Mizokawa, 1990).

However, verbal and nonverbal scores were available for both classrooms of Cohort 1 students at the spring of second grade. Because of decreased sample size over the four years of the study, it was decided to pool the two SIP Cohort 1 classrooms and use the spring grade 2

verbal and nonverbal scores as covariates. No significant differences in verbal ability as measured by the *Peabody Picture Vocabulary Test-Revised* (t = 1.26, df = 38, p = .21, two-tailed) or in nonverbal ability as measured by Raven's *Coloured Progressive Matrices* (t = .81, df = 38, p = .42) existed between the two SIP Cohort 1 classrooms in the spring of grade 2.

In a second series of analyses, the remaining members of the Cohort 2 of SIP children, 15 boys and 21 girls, were compared to their respective comparison classroom, with 11 boys and 6 girls remaining in 1991. The first cohort of children entered the Spanish-immersion program at its inception at the beginning of their first grade year, while the second cohort entered the SIP at kindergarten. Thus, at the time of this report, both cohorts had participated in Spanish-immersion education for five years.

The SIP and comparison classrooms are located in different schools in the same school district in Washington State, a middle-class area in rapid transition from suburb to city during the 4-year period of this research. The family background variables of both groups of children continue to be seen as comparable, with the SIP and regular classrooms both serving a population of middle-class English-speaking children from moderately diverse ethnic backgrounds. Some members of the SIP classrooms were English-Spanish or English-other language bilingual children prior to school entry.

No significant differences in gender (t = -.72, df= 58, p = .47, two-tailed) or age (t = -1.25, df = 58, p = .22, two-tailed) were revealed between the comparison and SIP classrooms of the first cohort at grade 2 in the spring of 1988. Likewise, no significant differences in age (t = 1.66, df = 58, p > .05, two tailed) or gender (t = 1.46, df = 58, p> .05, two-tailed) were shown between the second cohort of SIP children and their comparison classroom at grade 2 in 1989. Children who had repeated a grade, or are bilingual or special-program members of the comparison classrooms were tested but their scores were excluded from all analyses. In addition, scores from children whose parents reported a hearing deficit were also not included.

The SIP provides all school instruction in Spanish, with the exception of art, physical education and the patriotic songs portion of the music curriculum. English language-arts instruction begins in the second semester of grade 2. Participation in the SIP is voluntary, with children bussed into the SIP school from various attendance zones in the school district. At the time the children in this study entered the SIP, enrollment was on a first-come, first serve basis.

Instrumentation

The *Metropolitan Achievement Test, Sixth Edition,* (MAT6; Prescott, Balow, Hogan & Farr, 1986), was the measure of language and mathematics achievement for both the first and second cohorts at fourth grade. The MAT6 was administered state-wide in Washington State to fourth graders in 1990 and 1991. It is a norm-referenced

multiple-choice group test, and included reading, mathematics, and language subtests. Internal consistency reliability as assessed by the KR-20 formula was reported by the authors as .98 at grade 4. Alternate forms reliability is cited as ranging from .87 to .92 for the subtests analyzed in this report. Authors of the MAT6 assert that the validity of the test instrument may be derived from the five stages of procedures engaged in the development of the test.

The *Degrees of Reading Power*, (DRP; Touchstone Applied Science Associates, 1986), a test of reading comprehension, was the measure of reading achievement for the first cohort at fifth grade. The DRP is described by the authors as "holistic measures of how well messages within text are understood" (p. 1). A criterion-referenced, cloze-type test, the DRP presents the student with a passage of known difficulty from which a word has been omitted. The student's task is to select one word that correctly completes the passage from an array of 5 words. All words in the multiple-choice array are syntactically and semantically possible if the sentence which they complete is viewed in isolation. However, only one word is correct in the context of the passage presented to the student.

Internal consistency ratings for the DRP are high, with a KR-20 reliability coefficient of .94 reported by the authors for the target age group (Touchstone Applied Science Associates, 1986). Alternate form reliability is cited as ranging from .86-.88. The publishers of the DRP assert the construct validity of the test instrument in terms of their

operational definition of reading comprehension and the process required by the DRP of the student. Content validity is based on a random selection from all possible prose topics, as revealed by the entry list of the *Encyclopaedia Britannica*. In terms of criterion-related validity, research has shown a correlation of .83 between the DRP and the reading subtests of the *California Achievement Test*.

The *Bellevue Public Schools Mathematics Competency Test* (MCT), an unpublished test instrument, was the measure of mathematics achievement for the first cohort at grade 5. KR-20 reliability for the MCT is reported as .90 by the school district.

For children in the first cohort, the *Bellevue Public Schools Writing Sample* (BWS), a local test of writing ability, was not administered as scheduled at grade 5 because of the intrusion of a state-wide teachers' strike in the spring of 1991. Children in the second cohort will receive the DRP, MCT, and BWS at grade 5 in May, 1992.

Procedures

All children were tested in classroom groups during the regular school day under standard school district procedures for administration. Both cohorts of SIP children had received the MAT6 prior to the agreement between the school district and the researchers to conduct the present wave of the study, although the outcomes of the testing were not yet available to the researchers. The grade 5 achievement tests were administered after the design of the study.

This research employed a quasi-experimental pretest-posttest design (Campbell & Stanley, 1963). Program was the independent variable in all comparisons. In the first two analyses, achievement of each cohort on the language-arts and mathematics subtests of the MAT6 at grade 4 was the dependent variable. In the third comparison, reading achievement of Cohort 1 children at grade 5 as measured by the DRP was the dependent variable. In the final analysis, mathematics achievement of the Cohort 1 groups at grade 5 was the dependent variable.

Results

Metropolitan Achievement Tests

Cohort 1. A MANCOVA was applied to scores of the Cohort 1 SIP and comparison children on the Total Reading, Total Mathematics and Total Language subtest scores on the *Metropolitan Achievement Test,* with grade 2 measures of nonverbal ability as measured by Raven's *Coloured Progressive Matrices* (CPM; Raven, 1977) and grade 2 scores of verbal ability as measured by the *Peabody Picture Vocabulary Test-Revised* (PPVT-R; Dunn, Dunn, Robertson & Eisenburg, 1981), sex and age as covariates. The use of the grade 2 verbal and nonverbal scores of the children as covariates in the analysis of their achievement scores at grade 4 seeks to ensure that any differences in intellectual ability that may have existed between the SIP and comparison groups at the beginning of the study have been adequately controlled. For means

and standard deviations of the Cohort 1 SIP and comparison groups on the MAT6 subtests, see Table 1.

Insert Table 1 about here

Significant differences in Total Reading, Total Mathematics and Total Language subscores between the two Cohort 1 groups were revealed using Hotelling's T^2 criterion, $F = 6.11$, $P = .002$. Subsequently, univariate F tests among the various subtests were conducted among the subscores of the MAT6, with grade 2 PPVT-R, CPM, sex and age as covariates, to show where the significant differences between the two groups may exist. The means and standard deviations of the 2 groups on the MAT6 subtest scores are displayed in Table 2.

Insert Table 2 about here

Univariate F tests demonstrated significant differences in favor of the comparison classroom on the word recognition ($F(1,36) = 8.71$, $p = .006$), spelling ($F(1,36) = 9.04$, $p = .005$), and language ($F(1,36) = 5.36$, $p = .026$) subtest scores. In contrast, on the mathematics computation subtest between-group differences in favor of the immersion children approached significance, $F(1,36) = 3.41$, $p = .07$).

Cohort 2. Likewise, a MANCOVA was applied to the Total Reading, Total Language, and Total Mathematics subtest scores of the

Cohort 2 SIP and comparison children with the PPVT-R, CPM, sex and age as covariates. No significant differences were shown between groups, using Hotelling's T^2 criterion. For means and standard deviations, see Table 3.

Insert Table 3 about here

Grade 5 Achievement Tests

Finally, a MANCOVA applied to the scores of the first cohort of SIP and comparison children on the MCT and DRP at grade 5, again using the CPM, PPVT-R, sex and age as covariates, revealed no significant differences between groups. Means and standard deviations of the two Cohort 1 groups on the grade 5 achievement tests may be found in Table 4.

Insert Table 4 about here

Post Hoc Analyses

Interest in the relative strength of the mathematics achievement of the first cohort of SIP children in contrast to their reading/language achievement at grade 4 prompted a post hoc analysis to investigate the relationship between the bilingual ability of the children in the primary grades and their grade 4 mathematics competency. As Hakuta (1987) pointed out, if bilingual competence contributes to the

development of nonverbal skills, then the degree of bilingualism achieved by the immersion children in the early school years may predict the subsequent development of nonverbal ability, operationalized in this study as mathematics achievement.

Consequently, a regression analysis was conducted with bilingual ability at grade 2 as the predictor variable, and the MAT6 mathematics concepts, mathematics computation and mathematics problem-solving subtests as outcome measures. Degree of bilingualism at second grade was measured by scores on the *Test de Vocabulario en Imágenes Peabody,* (TVIP; Dunn, Padilla, Lugo & Dunn, 1986), a test of listening Spanish vocabulary that had been individually administered to the SIP children at grade 2. The TVIP is a reliable instrument, with split-half reliability reported by the authors to range from .91 to .94 for primary-grade children.

Among the Cohort 1 immersion children, results of the regression analysis indicated a significant relationship between the TVIP scores at grade 2 and the mathematics concepts subtest scores at grade 4, $r = .49$, $p = .009$. Likewise, the grade 2 TVIP scores significantly predicted the grade 4 mathematics problem-solving subtest scores, $r = .56$, $p = .002$. However, there was no significant relationship demonstrated between the second grade TVIP scores and the fourth grade mathematics computation subtest scores ($r = .28$, $p = .16$).

In contrast, among the Cohort 2 group, no significant relationship was shown between grade 2 bilingual development and

mathematics concepts (r = .20, p = .28), mathematics computation (r = .08, p = .12) nor mathematics problem-solving (r = .00, p = .62) subtests of the MAT6 at grade 4.

Discussion

Mathematics Achievement

Prior longitudinal investigations of the cognitive development of children in immersion programs have reported significant gains in nonverbal ability by the children over their peers in monolingual classrooms, including an early report of this investigation at grade 2 (Bamford & Mizokawa, 1991; Samuels & Griffore, 1979). Over the course of the second grade, a portion of the students from the Cohort 1 immersion group of this study demonstrated significant gains in nonverbal problem-solving over the comparison classroom. However, in spite of their early gains in nonverbal performance in second grade, no clear indication of enhanced development was shown here in mathematics achievement scores at grades 4 and 5. Only in terms of mathematical computation did differences in favor of the first cohort of immersion children approach significance at grade 4. However, this possible advantage was not sustained the following year when no significant differences were observed between groups in mathematics achievement at grade 5.

While the finding of no significant differences between the immersion and comparison classrooms in mathematics achievement was disappointing in terms of demonstrating an influence of bilingual

development on nonverbal ability, the results of the MAT6 at grade 4 and the MCT at grade 5 nevertheless indicate that after 5 years of education in Spanish the SIP children in both cohorts demonstrate mathematics competency on a par with equivalent groups of children educated in English. Because both cohorts of SIP children and their comparison classrooms are highly able groups as revealed by their Raven's and PPVT-R scores in the primary grades (Bamford & Mizokawa, 1991b), this is a far stronger statement of competence than a comparison of SIP scores to school district norms. In addition, these data provides evidence of transfer of mathematics skills from acquisition in the second language to test performance in the native language (e.g., Cummins, 1987).

A post hoc analysis examined the relationship between the degree of bilingualism achieved by the first cohort of immersion children at the end of grade 2 and their subsequent mathematics achievement at grade 4. Here the children's bilingual ability at second grade significantly predicted their fourth grade achievement in mathematical concepts and problem-solving but not in mathematical computation. The demonstration of a relationship between bilingual development and subsequent nonverbal ability, operationalized here as mathematics achievement, is consistent with the results of Hakuta's (1987) research among Spanish-English bilingual education children in New Haven, Connecticut. In Hakuta's investigation, bilingual ability predicted later nonverbal problem-solving ability measured scores on

the *Raven's Matrices* at several points among data from three cohorts of primary and intermediate grade children.

Vygotsky (1934/1986) argued that mathematical concepts have a hierarchical relationship ranging from a school child's preconceptual understanding of arithmetic through the truly conceptual algebraic thought of the adolescent. The relationship observed here between earlier bilingual development and later ability in mathematical concepts and problem-solving, if viewed in Vygotsky's terms, may be seen as a positive relationship between bilingualism and higher-order mathematical ability, while no relationship was demonstrated between bilingualism and the lower-level computational skills. The first cohort thus provides evidence in support of Vygotsky's argument for the development of higher mental processes through the study of systems of knowledge such as language and mathematics (Vygotsky, 1934/1986).

Language Achievement

Although Harley, Hart and Lapkin (1986) found in their retrospective analysis that French-immersion children gained more in language-arts skills than their matched monolingual counterparts, this investigation revealed no significant differences in most comparisons of language-arts achievement. However, deficits were shown among the children in the first cohort of the Spanish immersion program at grade 4. Specifically, the comparison group outperformed the immersion children on word recognition, spelling and language subtests of the *Metropolitan Achievement Test* (MAT6).

The word recognition skills subtest of the MAT6 evaluates a child's ability to match phonemes and graphemes set in words. In addition, skill in using word-part clues is assessed. According to the authors, interpretation of performance on this subtest should include a consideration of "the importance or degree of emphasis to be placed on the teaching" (p. 27, 29, 31) of consonant, vowel and word part clue skills in the educational program. English language-arts instruction began in the second semester of grade 2 for the Spanish-immersion children, with 30 minutes per day provided. English instruction was subsequently increased to 45 minutes daily in the fall of grade 3, and to 1-hour per day beginning in the second semester of the third grade. English language-arts instruction in both the SIP and regular program uses the *whole language* method, which according to teacher reports, does not emphasize grapheme/phoneme matching skills. For the regular program students, whole language instruction is provided for 1.5 hours each day and is integrated across the curriculum throughout the school day.

Studies of French-immersion students indicate that any initial lag in English language-arts achievement is no longer observed in subsequent testing (Barik & Swain, 1975; Barik & Swain, 1976; Gray, 1986; Genesee, Holobow, Lambert, Cleghorn & Walling, 1985; Shapson & Day, 1982). Unfortunately, because a state-wide teachers' strike intervened in the spring of grade 5, the English writing sample was not administered to this cohort. As a result there is no information

available to clarify whether the deficit in language mechanics revealed here at grade 4 would be shown again the following year.

At grade 5 the only measure of verbal achievement was the DRP, a test of reading development, and no significant differences were seen between the immersion and standard-program groups of Cohort 1. Thus, the weak grade 4 performance by the first cohort in word recognition skills does not seem to be translated into a deficiency in reading ability at grade 5, at least as measured by the DRP. This indication of a transient delay is compatible with the reports from studies of French-immersion children cited above.

For the second cohort of SIP children, language-arts achievement was shown not to be significantly different from that of their comparison classroom at grade 4. Again, the data here do not favor the argument that additive-bilingual children may demonstrate gains in language development over their monolingual peers. However, the performance of the second cohort does add support for the more conservative assertion of the developmental-interdependence hypothesis of Skutnabb-Kangas and Toukomaa (cited in Cummins, 1981) from data among children in a Spanish-immersion program that is isolated from a major Spanish-speaking community.

The fact that deficits in some language skills were shown only by the first cohort of SIP children and not by the Cohort 2 group the following year suggests that the lag in performance of the Cohort 1 group on language mechanics may be an artifact of development of the

standard whole language methodology to an abbreviated format to fit program constraints in the start-up years of the SIP. The second cohort children have not yet participated in grade 5 achievement testing, and it remains to be seen whether their achievement may provide evidence to support the argument for enhanced language abilities among additive-bilingual children.

In summary, the fourth year of this study provided new evidence of the relationship between the degree of bilingual development in the primary years and subsequent higher-order mathematical skills, thus supporting Vygotsky's theory of cognitive development. However, while an earlier report of this longitudinal view had shown significant gains in nonverbal development by the Spanish immersion children at second grade, the mathematics and language achievement data do not indicate a corresponding advantage for the immersion children at fourth and fifth grades. At the intermediate grades the immersion children were generally performing on a par with their monolingual comparison class on standardized tests of achievement. Thus, after five years in immersion education, inferences from the performance of the Spanish-immersion children must be limited to support of the developmental-interdependence hypothesis.

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Table 1

Means and Standard Deviations of Immersion and Comparison Cohort 1 Groups on Metropolitan Achievement Test-Subscores

		Immersion	Comparison
Total Reading			
	n	27	15
	M	624.85	648.20
	SD	49.63	51.19
Total Language			
	n	27	15
	M	595.19**	620.73**
	SD	29.81	32.76
Total Mathematics			
	n	27	15
	M	602.11	595.80
	SD	38.63	23.73

Note. *$p < .05$, **$p < .01$

Table 2

Means and Standard Deviations of Immersion and Comparison Cohort 1 Groups on Subtests of the Metropolitan Achievement Test

		Immersion	Comparison
Vocabulary			
	n	27	15
	M	625.37	627.00
	SD	48.78	40.85
Word Recognition			
	n	27	15
	M	618.59**	656.93**
	SD	45.01	50.51
Reading Comprehension			
	n	27	15
	M	631.89	646.40
	SD	60.89	52.12
Mathematics: Concepts			
	n	27	15
	M	603.04	599.00
	SD	32.49	26.26

Mathematics: Computation			
	n	15	15
	M	589.04	571.20
	SD	39.35	25.09
Mathematics: Problem Solving			
	n	27	15
	M	607.11	622.93
	SD	50.84	39.68
Spelling			
	n	27	15
	M	577.41**	616.87**
	SD	40.85	45.38
Language			
	n	27	15
	M	606.96*	625.93*
	SD	31.16	33.25

Note. *$p < .05$, **$p < .01$

Table 3

Means and Standard Deviations of Immersion and Comparison Cohort 2 Groups on the Metropolitan Achievement Test-Subscores

		Immersion	Comparison
Total Reading			
	n	26	13
	M	614.42	612.15
	SD	50.72	53.99
Total Language			
	n	26	13
	M	592.54	592.92
	SD	30.91	27.49
Total Mathematics			
	n	26	13
	M	595.04	589.62
	SD	33.55	38.09

Table 4

Means and Standard Deviations of Immersion and Comparison Cohort 1 Groups on Grade 5 Achievement Tests

		Immersion	Comparison
Degrees of Reading Power			
	n	28	14
	M	63.11	63.93
	SD	12.67	11.55
Mathematics: Calculation			
	n	28	14
	M	86.46	82.93
	SD	11.64	11.73
Mathematics: Problem Solving/Application			
	n	28	14
	M	75.21	72.21
	SD	12.75	14.75